TELECOMMUNICATION SYSTEMS WITH WIRELESS TELECOMMUNICATION BETWEEN MOBILE AND/OR STATIONARY TRANSMISSION/RECEPTION DEVICES BASED ON CODE-DIVISION AND TIME-DIVISION MULTIPLEX

Telecommunication systems with wireless telecommunication between mobile and/or stationary transmission/reception devices are specific message systems having a message transmission link between a message source and a message sink wherein, for example, base stations and mobile parts for message processing and transmission are employed as transmission and reception devices, and wherein

1) the message processing and message transmission can ensue in a privileged transmission direction (simplex mode) or in both transmission directions (duplex mode),

2) the message processing is preferably digital,

3) the message transmission via the long-distance transmission link ensues wirelessly on the basis of various message transmission methods for multiple utilization of the message transmission link FDMA (**F**requency **D**ivision **M**ultiple **A**ccess), TDMA (**T**ime **D**ivision **M**ultiple **A**ccess) and/or CDMA (**C**ode **D**ivision **M**ultiple **A**ccess) -- for example, according to radio standards such as **DECT** [**D**igital **E**nhanced (previously: **E**uropean) **C**ordless **T**elecommunication; see *Nachrichtentechnik Elektronik 42 (1992) Jan./Feb., No. 1, Berlin, DE; U. Pilger, "Struktur des DECT-Standards" pages 23 through 29* **in combination with** the ETSI Publication *ETS 300175-1...9, October* 1992 and the DECT publication of *DECT-Forum, February 1997, pages 1 through 16*], **GSM** [**G**roupe **S**péciale **M**obile or **G**lobal **S**ystem for **M**obile Communication; see *Informatik Spektrum 14 (1991), June, No. 3, Berlin, DE; A. Mann, "Der GSM-Standard -- Grundlage für digitale europäische Mobilfunknetze", pages 137 through 152* **in combination with** the publication *telekom praxis 4/1993, P. Smolka "GSM-Funkschnittstelle -- Elemente und Funktionen", , pages 17 through 24*], **UMTS** [**U**niversal **M**obile **T**elecommunication **S**ystem; see **(1)**: *Nachrichtentechnik Elektronik, Berlin 45, 1995, No. 1, pages 10-14 and No. 2, pages 24-27; P. Jung, B. Steiner, "Konzept eines*

CDMA-Mobilfunksystems mit gemeinsamer Detektion für die dritte Mobilfunkgeneration"; **(2)**: *Nachrictentechnik Elektronik, Berlin 41, 1991, No. 6, pages 223-227 and page 234; P. W. Baier, P. Jung, A. Klein, "CDMA -- ein günstiges Vielfachzugriffsverfahren für frequenzselektive und zeitvariante Mobilfunkkanäle";* **(3)**: *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences, Vol. E79-A, No. 12, December 1996, pages 1930-1937; P. W. Baier, P. Jung, "CDMA Myths and Realities Revisited"*; **(4)**: *IEEE Personal Communications, February 1995, pages 38-47; A. Urie, M. Streeton, C. Mourot, "An Advanced TD MA Mobile Access System for UTMS"*; **(5)**: *telekom praxis, 5/1995, pages 9-14; P. W. Baier, "Spread-Spectrum-Technik und CDMA -- eine ursprünglich militärische Technik erobert den zivilen Bereich"*; **(6)**: *IEEE Personal Communications, February 1995, pages 48 through 53; P. G. Andermo, L. M. Ewerbring, "An CDMA-Based Radio Access Design for UMTS" ;* **(7)**: *ITG Fachberichte 124 (1993), Berlin, Offenbach, VDE Verlag ISBN 3-8007-1965-7, pages 67-75; Dr. T. Zimmermann, Siemens AG, "Anwendung von CDMA in der Mobilkommunikation"*; **(8)**: *telcom report 16, (1993), No. 1, pages 38-41; Dr. T. Ketseoglou, Siemens AG and Dr. T. Zimmermann, Siemens AG, "Effizienter Teilnehmerzugriff für die 3. Generation der Mobilkommunikation -- Vielfachzugriffsverfahren CDMA macht Luftschnittstelle flexibler"*; **(9)**: *Funkschau 6/98, R. Sietmann, "Ringen um die UMTS-Schnittstelle", pages 76-81*] WACS or PACS, IS-54, IS-95, PHS, PDC, etc. [see IEEE Communications Magazine, January 1995, pages 50-57; D. D. Falconer et al., "Time Division Multiple Access Methods for Wireless Personal Communications"].

"Message" is a higher-ranking term that stands both for the meaning (information) as well as for the physical representation (signal). Despite the same meaning of a message -- i.e. the same information --, different signal forms can occur. Thus, for example, a message relating to a subject can be transmitted

(1) in the form of an image,

(2) as a spoken word,

(3) as a written word,

(4) as an encrypted word or image.

The type of transmission according to (1)...(3) is thereby normally characterized by continuous (analog) signals, whereas discontinuous signals (for example, pulses, digital signals) usually arise given the type of transmission according to (4).

The following Figures 1 through 7 show:

Figure 1 "three-layer structure" of a WCDMA/FDD radio interface in the "downlink";

Figure 2 "three-layer structure" of a WCDMA/FDD radio interface in the "uplink";

Figure 3 "three-layer structure" of a TDCDMA/TDD radio interface;

Figure 4 radio scenario with channel multiple-use according to frequency-division, / time-division, / code-division multiplex;

Figure 5 the basic structure of a base station fashioned as transmission/reception device;

Figure 6 the basic structure of a mobile station likewise fashioned as transmission/reception device;

Figure 7 a DECT transmission time frame.

In the UMTS scenario (3rd mobile radiotelephone generation or, respectively, IMT-2000), there are two sub-scenarios, for example according to the publication *Funkschau 6/98, R. Sietmann, "Ringen um die UMTS-Schnittstelle", pages 76-81.* In a first sub-scenario, the licensed, coordinated mobile radiotelephone will be based on a WCDMA technology (**W**ideband **C**ode **D**ivision **M**ultiple **A**ccess) and, as in GSM, will operate in the FDD mode (**F**requency **D**ivision **D**uplex), whereas the unlicenced, uncoordinated mobile radiotelephone in a second sub-scenario will be based on a TD-CDMA technology (**T**ime **D**ivision-Code **D**ivision **M**ultiple **A**ccess) and, as in DECT, will operate in the TDD mode (**F**requency **D**ivision **D**uplex)

For the WCDMA/FDD mode of the universal mobile telecommunication system, the radio interface of the telecommunication system respectively contains a plurality of physical channels in upstream and downstream direction according to the publication *ETSI STC SMG2 UMTS-L1, Tdoc SMG2 UMTS-L1 163/98, "UTRA Physical Layer Description FDD Parts", Vers. 0.3, 1998-05-29*, a first physical channel thereof, what is referred to as the **D**edicated **P**hysical **C**ontrol **CH**annel

DPCCH, and a second physical channel thereof, what is referred to as the **D**edicated **P**hysical **D**ata **CH**annel DPDCH, [...] with reference to a "three-layer structure" composed of 720 ms long (T_{FZR}=720ms) super frames MZR, 10 ms long (T_{FZR}=10 ms) radio frames ZR and 0.625 ms long (T_{ZS}=0.625 ms) time slots ZS that are shown in Figures 1 and 2. The respective super frame MZR contains, for example, 72 radio frames, whereas each radio frame ZR in turn comprises, for example, 16 time slots ZS1...ZS16. As burst structure with respect to the first physical channel DPCCH, the individual time slot ZS, ZS1...ZS16 (burst) comprises a pilot sequence PS with N_{pilot} bits for channel estimating, a TPC sequence TPCS with N_{TPC} bits for traffic power control and a TFC1 sequence TFCIS with N_{TFCI} bits for traffic format channel indication as well as a payload data sequence NDS with N_{Data} bits with respect to the second physical channel DPDCH.

The first physical channel ["dedicated physical control channel (DPCCH)] and the second physical channel ["dedicated physical data channel (DPDCH)] are time-multiplexed in the downlink (downstream direction of the telecommunication; radio connection from the base station to the mobile station) of the WCDMA/FDD system of ETSI or, respectively, ARIB – Figure 1 –, whereas an I/Q multiplex wherein the second physical channel DPDCH is transmitted in the I-channel and the first physical channel DPCCH is transmitted in the Q-channel occurs in the uplink (upstream direction of the telecommunication; radio connection from the mobile station to the base station) – Figure 2.

According to the publication, *TSG RAN WG1 (S1.21): "3rd Generation Partnership Project (3GPP)", Vers. 0.0.1, 1999-01*, the radio interface of the telecommunication system in upstream and downstream direction of the telecommunication for the TDCDMA/TDD mode of the universal mobile telecommunication system is again based on the "three-layer structure" composed of the super frame MZR, the radio frame ZR and the time slots ZS for all physical channels that is shown in Figure 3. The respective super frame MZR again contains, for example, 72 radio frames ZR, whereas each radio frame ZR again, for example, comprises the 16 time slots ZS, ZS1,...ZS16. The individual time slot ZS, ZS1...ZS16 (burst) either comprises – according to the ARIB proposal – a first time slot structure

(burst structure) ZSS1 composed, in sequence, of a first payload data sequence NDS1 with N_{Data1} bits, of the pilot sequence PS with N_{pilot} bits for channel estimating, of the TCP sequence TPCS with N_{TPC} bits for power control, of the TFCI sequence TFCIS with N_{TFCI} bits for transport format indication, of a second payload data sequence NDS2 and of a guard period having N_{Guard} bits or – according to the ETSI proposal – a second time slot structure (burst structure) ZSS2 composed, in sequence, of the first payload data sequence NDS1, of a first TFCI sequence TFCIS1, of a midamble sequence MIS for channel estimating, of a second TFCI sequence TFCIS2, of the second payload data sequence NDS2 and of the guard time SZZ.

On the basis of, for example, a GSM radio scenario with, for example, two radio cells and base stations (**B**ase **T**ransceiver **S**tation) arranged therein, Figure 4 shows [...], whereby a first base station BTS1 (transmitter/receiver) omnidirectionally "illuminates" a first radio cell FZ1 and a second base station omnidirectionally "illuminates" a second radio cell, and, proceeding from Figures 1 and 2, a radio scenario with channel multiple utilization according to the frequency-division/time-division/code-division multiplex, whereby the base stations BTS1, BTS2 are connected or, respectively, connectable – via a radio interface designed for the radio scenario – to a plurality of mobile stations MS1...MS5 (transmission/reception device) located in the radio cells by wireless unidirectional or bidirectional – downstream direction UL (uplink) and/or downstream direction DL (downlink) – telecommunication on corresponding transmission channels TRC. The base stations BTS1, BTS2 are connected in a known way (see GSM telecommunication system) to a base station controller BSC that assumes the frequency management and switching functions in the framework of the control of the base stations. The base station controller BSC is in turn connected via a mobile switching center MSC to the higher-ranking telecommunication network, for example the PSTN (public switched telecommunication network). The mobile switching center MSC is the administration center for the illustrated telecommunication system. It assumes the complete call administration and – with associated registers (not shown) – the authentification of the telecommunication subscribers as well as the location monitoring in the network.

Figure 5 shows the fundamental structure of the base station BTS1, BTS2 fashioned as transmission/reception device, whereas Figure 6 shows the basic structure of the mobile station MS1...MS5 likewise fashioned as transmission/reception device. The base station BTS1, BTS2 assumes the sending and receiving of radio messages from and to the mobile station MS1...MS5, whereas the mobile stations MS1...MS5 assumes the sending and receiving of radio messages from and to the base station BTS1, BTS2. To this end, the base station comprises a transmission antenna SAN and a reception antenna EAN, whereas the mobile station MS...MS5 comprises an antenna ANT shared for sending and receiving that can be controlled by an antenna switchover means AU. In the upstream direction (reception path), the base station MTS1, BTS2 receives, for example, at least one radio message FN via the reception antenna with a frequency/time/code component from at least one of the mobile stations MS1...MS5, whereas the mobile station MS1...MS5 receives, for example, at least one radio message FN with a frequency/time code component in the downstream direction (reception path) from at least one base station BTS1, BTS2 via the shared antenna ANT. The radio message FN is thereby composed of a carrier signal spread broad-band that has an information composed of data symbols modulated onto it.

The received carrier signal is filtered in a radio reception means FEE (receiver) and is mixed down onto an intermediate frequency that is in turn subsequently sampled and quantized. Following an analog/digital conversion, the signal, which has been distorted bu multipath propagation on the radio link, is supplied to an equalizer EQL that largely compensates the distortions (catchword: synchronization).

Subsequently, an attempt is made in a channel estimator KS to estimate the transmission properties of the transmission channel TRC on which the radio message FN has been transmitted. The transmission properties of the channel are thereby indicated in the time domain by the channel pulse response. So that the channel pulse response can be estimated, a specific auxiliary information in the form of what is referred to as a midamble fashioned as training information sequence is assigned or, respectively, allocated to the radio message FN at the transmission side (by the mobile

station MS1...MS5 or, respectively, by the base station BTS1, BTS2 in the present case).

In a data detector DD that follows thereupon and is shared by all received signals, the individual mobile station-specific signal parts contained in the shared signal are distortion-corrected and separated in a known way. After the distortion-correction and separation, the previously existing data symbols are converted into binary data in a symbol-to-data converter SDW. The original bit stream is subsequently acquired from the intermediate frequency in a demodulator DMOD before the individual time slots are allocated to the correct logical channels in a demultiplexer DMUX and, thus, to the different mobile stations as well.

The received bit sequence is decoded in a channel codec KC. Dependent on the channel, the bit information are allocated to the control and signalling time slot or to a voice time slot and – in the case of the base station (Figure 5) – the control and signalling data and the voice data for transmission to the base station controller BSC are handed over in common to an interface SS responsible for the signalling and voice encoding/decoding (voice codec), whereas – in the case of the mobile station (Figure 6) – the control and signalling data are handed over to a control and signalling unit STSE responsible for the complete signalling and control of the mobile station, and the voice data are handed over to a voice codec SPC designed for the voice input and output.

The voice data [...] in a predetermined data stream (for example, 64 kbit/s stream in network direction or, respectively, 13 kbit/s stream from network direction) in the voice codec of the interface SS in the base station BTS1, BTS2.

The complete control of the base station BTS1, BTS2 is implemented in a control unit STE.

Via the transmission antenna SAN, the base station BTS1, BTS2 sends, for example, at least one radio message FN with a frequency/time/code component to at least one of the mobile stations MS1...MS5 in the downstream direction (transmission path) via the transmission antenna, whereas the mobile station MS1...MS5 sends, for example, at least one radio message with a frequency/time/code component to at least

one base station BTS1, BTS2 in the upstream direction (transmission path) via the shared antenna ANT.

In Figure 5, the transmission path begins at the base station BTS1, BTS2 therewith that the base station controller BSC allocates control and signalling data as well as voice data received via the interface SS to a control and signalling time slot or to a voice time slot in the channel codec KC and these are encoded into a bit sequence channel-by-channel.

In Figure 6, the transmission path begins at the mobile station MS1...MS5 in that voice data received from the voice codec SPC and control and signalling data received from the control and signalling unit STSE are allocated to a control and signalling time slot or to a voice time slot in the channel codec KC and these are encoded into a bit sequence channel-by-channel.

The bit sequence acquired in the base station BTS1, BTS2 and in the mobile station MS1...MS5 is respectively converted into data symbols in a data-to-symbol converter DSW. Following thereupon, the data symbols are respectively spread with a respective, subscriber-individual code in a spreader means SPE. In the burst generator BG composed of a burst compiler BZS and a multiplexer MUX, a training information sequence in the form of a midamble for channel estimation is subsequently respectively attached to the spread data symbols in the burst compiler BZS, and the burst information obtained in this way is set to the respectively correct time slot in the multiplexer MUX. As a final step, the obtained burst is respectively modulated high-frequency in a modulator MOD and is converted digital-to-analog before the signal obtained in this way is beamed out – as radio message FN – to the transmission antenna SAN or, respectively, to the shared antenna ANT via a radio transmission means FSE (transmitter).

TDD telecommunication systems (**T**ime **D**ivision **D**uplex) are telecommunication systems wherein the transmission time frame composed of a plurality of time slots is divided -- preferably in the middle – for the downstream transmission direction (downlink) and the upstream transmission direction (uplink).

A TDD telecommunication system that comprises such a transmission time frame is, for example, the known DECT system [**D**igital **E**nhanced (previously:

European) Cordless Telecommunication; see *Nachrichtentechnik Elektronik 42 (1992) Jan./Feb., No. 1, Berlin, DE; U. Pilger, "Struktur des DECT-Standards" pages 23 through 29* **in combination with** the ETSI Publication *ETS 300175-1...:9, October* 1992 and the DECT publication of *DECT-Forum, February 1997, pages 1 through 16*].

Figure 7 shows a DECT transmission time frame with a time duration of 10 ms composed of 12 downlink time slots and 12 uplink time slots. According to the DECT standard, a free time slot pair with a downlink time slot ZS_{DOWN} and an uplink time slot ZS_{UP} is selected for an arbitrary bidirectional telecommunication connection on a predetermined frequency in downstream transmission direction DL (downlink) and upstream transmission direction UL (uplink), whereby the spacing between the downlink time slot ZS_{DOWN} and the uplink time slot ZS_{UP} amounts to half the length (5 ms) of the DECT transmission time frame, likewise according to the DECT standard.

FDD telecommunication systems (**F**requency **D**ivision **D**uplex) are telecommunication systems wherein the time frame, composed of a plurality of time slots, is transmitted in a first frequency band for the downstream transmission direction (downlink) and in a second frequency band for the upstream transmission direction (uplink).

An FDD telecommunication system that transmits the time frame in this way is, for example, the known GSM system [**G**roupe **S**péciale **M**obile or **G**lobal **S**ystem for **M**obile Communication; see *Informatik Spektrum 14 (1991), June, No. 3, Berlin, DE; A. Mann, "Der GSM-Standard -- Grundlage für digitale europäische Mobilfunknetze", pages 137 through 152* **in combination with** the publication *telekom praxis 4/1993, P. Smolka "GSM-Funkschnittstelle -- Elemente und Funktionen",, pages 17 through 24*].

The radio interface for the GSM system recognizes a plurality of logical channels referred to as bearer services, thus, for example, an AGCH channel (**A**ccess **G**rant **CH**annel), a BCCH channel (**B**road**C**ast **CH**annel), an FACCH channel (**F**ast **A**ssociated **C**ontrol **CH**annel), a PCH channel (**P**aging **CH**annel), an RACH channel (**R**andom **A**ccess **CH**annel) and a TCH channel (**T**raffic **CH**annel) whose respective function in the radio interface is described, for example, in the publication *Informatik*

Spektrum 14 (1991), June, No. 3, Berlin, DE; A. Mann, "Der GSM-Standard -- Grundlage für digitale europäische Mobilfunknetze", pages 137 through 152 **in combination with** the publication *telekom praxis 4/1993, P. Smolka "GSM-Funkschnittstelle -- Elemente und Funktionen", , pages 17 through 24*. The GSM system also comprises a frame structure wherein the 13th time frame in every multi-frame having a length of 60 ms is fashioned as "idle" frame in the multi-frame. In this "idle" frame wherein no payload data are transmitted, the mobile stations in the GSM system are given the opportunity to implement various measurements, particularly measurements for pre-synchronization for possible handover procedures.

The greatest difference between the GSM system comprising a frequency and time level that is operated in a coordinated, licensed mode and the DECT system likewise comprising a frequency and time level that is operated in an uncoordinated, unlicenced mode is comprised in the way in which the physical resource "channel" is allocated to the system subscriber or, respectively, telecommunication subscriber.

In the coordinated, licenced telecommunication system, the channel allocation is controlled by a central entity, the network operator. This is possible because all mobile stations residing within a radio area of a base station use the same time base, i.e. are operated synchronously. The synchronous operation allows a clear definition of time slot boundaries and, thus, a clear separation of different telecommunication subscribers. Neighboring base stations need not be operate synchronously since the separation of channels that are used in neighboring radio cells generally ensues with a frequency planning in the frequency level. This type of channel allocation is called "fixed channel allocation (FCA)".

In the uncoordinated, unlicenced telecommunication system wherein such a central entity for the channel allocation is not present, the channels are initially dynamically selected -- "dynamic channel selection (DCS)" -- and then allocated. The frequency/time level thereby serves as platform or, respectively, "pool" both for the dynamic channel selection (DCS) as well as for the channel allocation. In such a system, the mobile part regularly monitors the frequency/time level and finally selects the frequency/time slot combination at which the transmission channel is disturbed least by occurring interference. In that neighboring base stations operating

uncoordinated and mobile parts are always asynchronous and the time bases therefore run into one another or, respectively, drift into one another, a situation often arises wherein the degree of interference reaches an unacceptable value. In this case, a handover of the telecommunication connection to a different channel, viz. a different frequency/time slot combination, must be initiated. This is called an "intra cell handover".

Since the WCDMA/FDD mode and the TDCDMA/TDD mode are to be utilized in common in the framework of the UMTS scenario (3rd mobile radiotelephone generation or, respectively, IMT-2000), the realization of a suitable handover procedure is indispensable, particularly for the above reasons, for telecommunication systems with wireless telecommunication between mobile and/or stationary transmission/reception devices based on code-division and time-division multiplex, in addition to an efficient dealing with the logical channels or, respectively, the bearer services (bearer handling).

For telecommunication systems with wireless telecommunication between mobile and/or stationary transmission/reception devices based on code-division and time-division multiplex, the object underlying the invention is comprised in specifying a method in the framework of a handover that enables the indication of a handover (handover indication) for different operating modes of the transmission/reception devices.

This object is respectively achieved by the features of patent claim 1.

The idea underlying the invention is comprised therein that -- according to claim 1 -- given telecommunication systems with wireless telecommunication between mobile and/or stationary transmission devices based on code-division and time-division multiplex and both in the TDD mode as well as in the FDD mode, a stationary transmission/reception device (BS) shuts off a broadcast signalling in an idle time-division multiplex frame of a multi-time frame, acquires an interference situation in a current telecommunication time slot pair by determining the noise power, compares a measured interference to a predetermined threshold. and, if the interference value is higher than or equal to the threshold, enters the interference value

in a channel selection list for a handover procedure and/or indicates a handover for the handover procedure.

Advantageous developments of the invention are recited in the subclaims.

An exemplary embodiment of the invention is explained with reference to Figures 8 through 10. These show:

Figure 8 a TDD time-division multiplex frame (modified) compared to the time frame in Figures 1 through 3 and the DECT transmission time frame in Figure 7 with respect to the plurality of time slots;

Figure 9 a channel allocation table for channels with a frequency, code and time-division multiplex component on the basis of the time-division multiplex frame according to Figure 8;

Figure 10 a message flowchart of a handover procedure.

Proceeding from the time frame in Figures 1 through 3 and the DECT transmission time frame in Figure 7, Figure 8 shows a (modified) TDD time-division multiplex frame ZMR with eight time slots ZS\`1...ZS\`8, whereby the first four time slots ZS\`1...ZS\`4 are provided for the downstream transmission direction DL, and the second four time slots ZS\`5...ZS\`8 are provided for the upstream transmission direction UL. The plurality of time slots has been reduced from “16" according to Figures 1 and 3 to “8" merely for presentation reasons for the channel allocation table in Figure 9 and has no limiting influence on the invention. On the contrary, the plurality of time slots can be varied more or less arbitrarily dependent on the telecommunication system, as can the other physical resources (for example, code, frequency, etc.).

On the basis of the time-division multiplex frame according to Figure 8, Figure 9 shows a channel allocation table for channels with a frequency-division, code-division and time-division multiplex component. The time-division multiplex component of this table covers the time slots ZS\`1...ZS\`8 with the TDD division according to Figure 8. The frequency-division multiplex component covers 12 frequencies FR1...FR12, whereas the code-division multiplex component contains 8 codes (pseudo-random signals) C1...C8.

Transmission path services fashioned as "bearer services", for example logical channels of the telecommunication system such as the control channel for signalling, the AGCH channel, the BCCH channel, the PCH channel, the RACH channel, the TCH channel and/or the FACCH channel that are required in the telecommunication system in the downstream direction and/or upstream direction are bundled on a first frequency FR1 in a code plane erected by the codes C1...C8. This bundling proves expedient for the aforementioned telecommunication systems because an unnecessary occupancy of time slots, i.e. of the resource "time", is thereby avoided.

Figure 9 shows a preferred embodiment according to which respectively all codes C1...C8 are preferably utilized for the bundling of said bearer services in a first time slot ZS`1 as a permanently prescribed (declared), first selection time slot on the first frequency in the downstream direction and in a fifth time slot ZS`5 as a permanently prescribed (declared), second selection time slot in the upstream direction. Of course, it is also possible to use fewer or, when more than these eight codes are available, more codes as well.

Given this bundling shown in Figure 9, for example, the codes C1...C8 are divided such in the first time slot ZS`1 that one code is reserved or, respectively, assigned for the control channel for the signalling and the AGCH channel, a further code is reserved or, respectively, assigned for the BCCH channel and the PCH channel, and the remaining six codes are reserved or, respectively, assigned for the TCH channel, whereas the codes C1...C8 in the fifth time slot ZS`5 are divided such that one code is reserved or, respectively, assigned for the RACH channel, a further code is reserved or, respectively, assigned for the FACCH channel for the handover indication and the remaining six codes are again reserved or, respectively, assigned for the TCH channel.

Over and above this, the spectral efficiency and/or the performance of the telecommunication system can be improved further when – as shown in Figure 9 – a respective plurality of bidirectional TDD telecommunication connections for which the physical resource "code, frequency, time" are respectively occupied partially the same and partially differently in downstream and upstream direction [...] for various connection scenarios, a first connection scenario VSZ1, a second connection scenario

VSZ2, a third connection scenario VSZ3, a fourth connection scenario VSZ4 and a fifth connection scenario VSZ5. For example, each connection scenario VSZ1...VSZ5 includes a first group of telecommunication connections G1, which is marked with a rising and falling hatching, and a second group of telecommunication connections G2 that is marked with a falling hatching. Each group thereby contains at least one bidirectional telecommunication connection.

In the first connection scenario VSZ1, the first group of telecommunication connections G1 on a second frequency FR2 occupies six codes – the first code C1, the second code C2, the third code C3, the fourth code C4, the fifth code C5 and the sixth code C6 – in downstream direction in a second time slot ZS`2 and in turn occupies the six codes C1...C6 in upstream direction in a sixth time slot ZS`6, whereas the second group of telecommunication connections G2 on the second frequency FR2 occupies the first code C1 in downstream direction in a fourth time slot ZS`4 and again occupies the first code C1 in upstream direction in an eighth time slot ZS`8.

The fourth time slot ZS`4 and the second time slot ZS`2 are downlink time slots ZS_{DOWN}, whereas the sixth time slot ZS`6 and the eighth time slot ZS`8 are uplink time slots ZS_{UP}.

For each telecommunication connection in the groups G1, G2, a first spacing AS1 between the downlink times slot ZS_{DOWN} and the uplink time slot ZS – according to the Prior Art (see Figure 7) – is as long as half the time-division multiplex frame ZMR. The spacing is thus a fraction of the length of the time-division multiplex frame ZMR, whereby the fraction has the value 0.5.

In the second connection scenario VSZ2, the first group of telecommunication connections G1 on a fourth frequency FR4 occupies the six codes C1...C6 in downstream direction in the fourth time slot ZS`4 and again occupies the six codes C1...C6 in upstream direction in the seventh time slot ZS`7, whereas the second group of telecommunication connections G2 on the fourth frequency occupies the codes C1...C4 in downstream direction in a second time slot ZS`2 and occupies the first code C1 and the second code C2 in upstream direction in the fifth time slot ZS`5.

The fourth time slot ZS`4 and the second time slot ZS`2 – as in the first connection scenario VSZ1 – are downlink time slots ZS_{DOWN}, whereas the seventh time slot ZS`7 and the fifth time slot ZS`5 are uplink time slots ZS_{UP}.

For each telecommunication connection in the groups G1, G2, a second spacing AS2 between the downlink times slot ZS_{DOWN} and the uplink time slot ZS is as long as a fraction (fractional distance) of the length of the time-division multiplex frame ZMR, whereby the fraction is dimensioned such and greater or smaller than the value 0.5 that the second spacing AS2 is fixed.

In the third connection scenario VSZ3, the first group of telecommunication connections G1 on a sixth frequency FR6 occupies the four codes C1...C4 in downstream direction in the second time slot ZS`2 and occupies the six codes C1...C6 as well as the seventh code C7 and the eighth code C8 in upstream direction on a fifth frequency FR5 in the eighth time slot ZS`8, whereas the second group of telecommunication connections G2 on the sixth frequency FR6 occupies the codes C1...C3 in downstream direction in the third time slot ZS`3 and occupies the codes C1...C4 in upstream direction in the fifth time slot ZS`5 on the fifth frequency FR5.

The second time slot ZS`2 and the third time slot ZS`3 are downlink time slots ZS_{DOWN}, whereas the eighth time slot ZS`8 and the fifth time slot ZS`5 are uplink time slots ZS_{UP}.

For each telecommunication connection in the groups G1, G2, a third spacing AS3 between the downlink time slot ZS_{DOWN} and the uplink time slot ZS is as long as a fraction (fractional distance) of the length of the time-division multiplex frame ZMR, whereby the fraction is respectively dimensioned such that the third spacing AS3 is variable.

In the fourth connection scenario VSZ4, the first group of telecommunication connections G1 on an eighth frequency FR8 occupies the first code C1 in downstream direction in the fourth time slot ZS`4 and occupies the seven codes C1...C7 in upstream direction on a ninth frequency FR9 in the sixth time slot ZS`9, whereas the second group of telecommunication connections G2 on the eighth frequency FR8 occupies the first code C1 in downstream direction in the third time

slot ZS`3 and occupies the first code C1 in upstream direction in the fifth time slot ZS`5 on the ninth frequency FR9.

The fourth time slot ZS`4 and the third time slot ZS`3 are downlink time slots ZS_{DOWN}, whereas the sixth time slot ZS`6 and the fifth time slot ZS`5 are uplink time slots ZS_{UP}.

For each telecommunication connection in the groups G1, G2, a fourth spacing AS4 between the downlink time slot ZS_{DOWN} and the uplink time slot ZS is as long as a fraction (fractional distance) of the length of the time-division multiplex frame ZMR, whereby the fraction is respectively dimensioned such that the fourth spacing AS4 is fixed.

In the fifth connection scenario VSZ5, the first group of telecommunication connections G1 on an eleventh frequency FR11 occupies the first code C1 and the second code in downstream direction in the fourth time slot ZS`4 and again occupies the first code C1 and the second code C2 in upstream direction in the fifth time slot ZS`5, whereas the second group of telecommunication connections G2 on the eleventh frequency FR11 occupies the codes C1...C5 in downstream direction in the first time slot ZS`1 and occupies the codes C1...C5 in upstream direction in the eighth time slot ZS`8.

The fourth time slot ZS`4 and the first time slot ZS`1 are downlink time slots ZS_{DOWN}, whereas the fifth time slot ZS`5 and the eighth time slot ZS`8 are uplink time slots ZS_{UP}.

For each telecommunication connection in the groups G1, G2, a fifth spacing AS5 between the downlink time slot ZS_{DOWN} and the uplink time slot ZS is as long as a fraction (fractional distance) of the length of the time-division multiplex frame ZMR, whereby the fraction is dimensioned such that the second [sic] spacing AS2 is variable.

Figure 10 shows a message flowchart of a handover procedure. The handover procedure is fundamentally composed of three phases, a first phase that is referred to as a handover indication, a second phase that is referred to as a handover initiation, and a third phase that is referred to as a handover execution, these being executed in the indicated sequence.

In case of a deterioration of the quality of service (QoS), a base station BS indicates a handover, i.e. a first phase of the handover procedure is started. Alternatively, the deterioration of the quality of service (QoS) can also have been detected by a mobile part, a first mobile part MT1, a second mobile part MT2 or an n^{th} mobile part MTn, that subsequently informs the base station BS of this deterioration, for example via the FACCH channel. In this case, the base station BS is the "master" with respect to the handover procedure, whereas the mobile part MT1...MTn is the "slave". However, it is also possible that the mobile part is the "master" with respect to the handover procedure and the base station is the "slave".

With the indication of a handover by the base station BS, this selects a "handover" time slot pair, for example on the basis of a channel selection list, wherein the quality of the service to be transmitted is better than in the existing telecommunication time slot pair. The "handover" time slot pair has already been determined in the first phase of the handover procedure, the handover indication.

The channel selection list is produced in the framework of the dynamic channel selection (DCS). To that end, the base station BS shuts off the signalling on the BCCH channel, acquires the interference situation in the GSM-specific "idle" frame by determining the noise power, for example by measuring the signal field strength, in the telecommunication time slot pair and stores the measured results (interference values) in the channel selection list. So that any old handover procedures are not constantly implemented on the basis of entries in the channel selection list (catchword: hysteresis effect), a threshold is defined that lies between the respectively currently acquired interference value and an interference value that belongs to the "quietest" time slot pair. The base station BS should not undertake an entry into the channel selection list and/or not indicate or initiate a handover when the predetermined threshold is not exceeded by the respectively acquired interference value.

The second phase of the handover procedure, the handover initiation, begins therewith that the base station BS sets up a BCCH channel in the downlink time slot of the handover time slot pair. In the traffic mode, the information (data services) sent

on the downlink time slot of the telecommunication time slot pair are simultaneously transmitted on this downlink time slot of the handover time slot pair.

Differing from the traffic mode, a simultaneous transmission of the information (data services) does not occur in the broadcast mode, wherein the second phase of the handover procedure is started in the same way.

After the successful setup of the BCCH channel in the downlink time slot of the handover time slot pair, the base station BS transmits a first message "Handover Request" M1 via the BCCH channel in the downlink time slot of the telecommunication time slot pair to the mobile parts MT1...MTn connected to the base station BS via this channel. The mobile parts MT1...MTn are informed of the position of the handover time slot pair with this first message M1. After the transmission of the first message M1, the base station BS continues the simultaneous transmission of the information (data services) in the downlink time slots of the telecommunication time slot pair and of the handover time slot pair and also transmits the first message M1 on the BCCH channel in the downlink time slots of the telecommunication time slot pair until all mobile parts MT1...MTn connected to the base station BS have acknowledged the initiation of the handover by the first message M1.

When the affected mobile parts MT1...MTn still have current data to transmit, the mobile parts MT1...MTn connected to the base station BS switch immediately from the telecommunication time slot pair to the handover time slot pair after receiving the first message M1. The data transmission in the telecommunication time slot pair is thereby ended and seamlessly continued in the handover time slot pair.

When, however, the affected mobile parts MT1...MTn still have current data to transmit, then the respective mobile part MT1...MTn transmits a second message "Handover Confirm" M2 to the base station BS on a signalling channel.

The base station BS thus receives, on the one hand, simultaneous data in the telecommunication time slot pair and the handover time slot pair and, on the other hand, the second message M2. The initiation of the handover by the first message M1 is ultimately viewed by the base station BS as having been confirmed when -- in the former instance -- the data transmitted from the respective mobile part MT1...MTn on

the uplink time slot of the handover time slot pair are received error-free by the base station or when -- in the latter instance -- the base station BS receives the second message M2.

The second phase of the handover, the handover initiation, is ended when all mobile parts MT1...MTn have confirmed the initiation of the handover by the first message M1.

In the third phase of the handover procedure, the handover execution, the transmission in the previous telecommunication time slot pair is ended in conclusion after all mobile parts MT1...MTn have confirmed the initiation of the handover by the first message M1; the handover time slot pair thus serves as new telecommunication time slot pair.